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ELECTRONICS AND ELECTRICAL ENGINEERING

No. 109

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ELECTRONICS AND ELECTRICAL ENGINEERING

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REFLECTIVITY OF SPHERICAL SHIELD

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian
Vol 26, No 1, Jan 83 (manuscript received 5 Apr 82) pp 91-102

VINOGRADOV, S. S., Institute of Radiophysics and Electronics, UkSSR Academy of Sciences

[Abstract] An ideally conducting spherical shield with a circular hole is considered in the path of a plane electromagnetic wave propagating along the axis of symmetry through the hole. Total and differential (radar) cross sections for scattering are calculated through a rigorous solution of the corresponding diffraction problem. The field of the wave is described by Debye electric and magnetic potentials satisfying the scalar Helmholtz equation with the appropriate boundary conditions. Correct formulation of the latter results in a pair of differential equations equivalent to one of the second order with a solution in the form of a coupled system of paired sum equations in Legendre polynomials. These are regularized to an infinite system of linear algebraic equations of the second kind with respect to the unknown coefficients of a series expansion in spherical wave functions, suitable for evaluation of Rayleigh scattering for an arbitrary central angle of the circular hole in the spherical surface. The calculations are extended to radar scattering, analytically for $k\alpha<1$ and numerically for $k\alpha\leq 10$ (α- radius of sphere, k- wave number). The results reveal a double resonanee, which can be attributed to interference of two waves in the far field: one wave backscattered by the outside surface of the shield, one wave generated inside the shield and leaving through the hole. Figures 5; references 12: 8 Russian, 4 Western (2 in translation).
[216-2415]

UDC 537.874.6:621.396.677

DIFFRACTION OF ELECTROMAGNETIC WAVES BY TWO-DIMENSIONALLY PERIODIC ARRAY OF SEMI-INFINITE DIELECTRIC RODS

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian
Vol 26, No 1, Jan 83 (manuscript received 9 Mar 82) pp 74-81

KREKHTUNOV, V. M. and TYULIN, V. A., Moscow Higher Technical School imeni N. E. Bauman

[Abstract] A two-dimensionally periodic structure consisting of parallel vertical dielectric rods in free space is considered, and the problem of diffraction of elecgromagnetic waves by such a structure is solved through algebraization for the case of quasi-periodic excitation of either a natural mode in the inner region or a plane wave in the homogeneous upper half-space at an arbitrary angle of incidence. The method of collocation of fields in projections is applied so that the solution automatically satisfies the condition of power balance. There is no closed analytical solution to the problem in the general case, but there is one for the case of a homogeneous Floquet channel. For any other specific case the solution must be tested for convergence. The algorithm according to the Galerkin method has been programmed in FORTRAN for a BESM-6 high-speed computer or YeS Unified System computers, to yield the coefficients of the scattering matrix. Numerical results obtained for the reflection coefficient in a typical case of a plane incident wave indicate that this algorithm is sufficiently accurate for engineering calculations. Figures 5; references 15: 12 Russian, 3 Western (2 in translation).
[216-2415]

UDC 538.574.4

AMPLIFICATION OF MEAN INTENSITY OF BACKSCATTERING IN TURBULENT ATMOSPHERE

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian
Vol 26, No 1, Jan 83 (manuscript received 16 Apr 82) pp 44-48

KASHKAROV, S. S., Institute of Atmospheric Physics, USSR Academy of Science

[Abstract] Amplification of backscattering during propagation of light through a surface layer of the atmosphere is analyzed on a theoretical and experimental basis. Theoretical relations are derived from those for a point source and a point scatterer, with smooth perturbations in the first approximation. These relations are then extended to a "rough" scatterer in an atmosphere with anywhere from weak to strong turbulence. The experiment was performed with a laser (wavelength $\lambda = 0.6328$ µm) operating in a single transverse mode, the beam being focused through a lens onto a point simulating a "source" of a directional spherical wave. A large rough scatterer was placed in the path of this spherical-wave light beam at

a distance L of either 650 or 1300 m. The radiation intensity was measured near a hole at the center of the scatterer, under conditions of a zero correlation coefficient for light intensity fluctuations. Ambient radiation was separated by means of a modulator covering the scatterer without closing the hole. Calculation of the backscattering from photoreceiver readings obtained with two photomultipliers indicate that amplification of the mean backscattering intensity must be taken into account in radar measurements with an aperture smaller than the characteristic dimension $\sqrt{\lambda L}$ and at distances from the source smaller than $\sqrt{\lambda L}$. The author thanks A. S. Gurvich, A. G. Vinogradov, Yu. A. Kravtsov and V. I. Tatarskiy for constant attention to the work. Figures 2; tables 1; references: 12 Russian.
[216-2415]

UDC 551.510

ATTENUATION OF HIGH-FREQUENCY RADIO WAVES IN LOWER HIGH-LATITUDE IONOSPHERE ARTIFICIALLY PERTURBED WITH STRONG RADIO EMISSION

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 26, No 1, Jan 83 (manuscript received 10 Jun 82) pp 3-6

MARTYNENKO, S. I., MISYURA, V. A., PIVEN', L. A., SOMOV, V. G., CHERNOGOR, L. F. and SHEMET, A. S., Kharkov State University

[Abstract] The lower high-latitude ionosphere in the Monchegorsk region was artificially perturbed with strong short-wave radio emission in an experiment performed at nights during the February-March 1978 period with equipment of the Polar Geophysical Institute. A radio wave with a carrier frequency close to 3.3 MHz, modulated at a frequency of approximately 1.5 kHz, was continuously emitted upward by a 10 MW transmitter. Measurements were made with 1.7-3.5 MHz probing pulse signals of 9 MW transmitter. Measurements were made with 1.7-3.5 MHz probing pulse signals of 9 MW power and 25 microsecond duration, using the ionospheric radiotechnical instrumentation of the Kharkov State University. The experiental data obtained in 60 test runs were evaluated systematically with respect to geomagnetic conditions, with the r_H-index (difference between maximum and minimum amplitudes of H-component of geomagnetic field intensity within a one-hour period) serving as a criterion for classifying the geomagnetic conditions into unperturbed, weakly or moderately perturbed, and strongly perturbed ones. The results reveal specular reflection and strong attenuation of probing pulse signals, with a relation found to exist between the beginning of pulse signal attenuation and the beginning of transmitter operation. No relation has been established between the beginning of perturbation relaxation and the end of transmitter operation, however, which suggests a trigger mechanism of stimulated attenuation. The authors thank I. N. Kapustin, A. A. Ul'yanchenko and A. M. Royzen for operation of the perturbation generating equipment, for delivery of data on ionospheric probing below the perturbation zone, and for assistance in organizing the experiments. Figures 3; references 4: 3 Russian, 1 Western.
[216-2415]

UDC 621.372.826:621.396.677.85

NATURAL MODES IN PERIODIC ARRAY OF RECTANGULAR LONGITUDINALLY MAGNETIZED FERRITE RODS

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 26, No 1, Jan 83 (manuscript received 5 May 82) pp 114-119

KREKHTUNOV, V. M. and LAVROV, A. V., Moscow Higher Technical School imeni N. E. Bauman

[Abstract] An algorithm of analyzis and design calculations is constructed for a two-dimensionally periodic array of rectangular longitudinally magnetized ferrite rods. The ferrite medium is described by the permeability tensor and the natural electromagnetic modes are determined from the corresponding eigenvalue field equation according to the Jacobi method. The corresponding boundary-value problem is solved through algebraization of the differential operator according to the Galerkin method. The accuracy of the solution can be estimated only through numerical analysis of its convergence. The procedure has been checked against the special cases of ferrite rods degenerating into dielectric ones and an array degenerating into a homogeneous medium. The algorithm has been programmed in FORTRAN for a YeS 1040 Unified System computer. This work was presented at the 8th All-Union Symposium on Diffraction and Propagation of waves (L'vov, 1981). Figures 4; tables 1; references 10: 8 Russian, 2 Western (both in translation).
[216-2415]

UDC 621.378.325

REFLECTION OF WAVE BEAMS BY SHIELD IN NONLINEAR MEDIUM

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 26, No 1, Jan 83 (manuscript received 9 Nov 81, after completion 16 Jun 82) pp 12-19

SUKHORUKOV, A. P. and TROFIMOV, V. A., Moscow State University

[Abstract] Reflection of an electromagnetic wave beam by a shield in a nonlinear medium is analyzed, a beam in such a medium being subject to self-focusing or defocusing. Thermal self-focusing and defocusing as well as defocusing by the Kerr mechanism are considered, the method of numerical simulation being applied to a tubular beam and a Gaussian one. Calculations have been made for a plane reflector and a parabolic reflector, with the reflection coefficient varied from 0 to 1. The results, describing the interaction of incident and reflected waves in terms of the radial (transverse) profile of intensity amplitude, indicate how the beam aperture can be optimized for maximum concentration of beam energy on a shield. The feasibility is demonstrated, with application of the similarity theory, on the simple case of a plane reflector with a radius larger than the beam radius. Figures 4; references: 5 Russian.
[216-2415]

UDC 533.607.13:535.311.25

TRANSFER FUNCTION OF MODULATION IN TV SHADOW DEVICE

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 1, Jan 83 (manuscript received 1 Apr 81) pp 8-10

NAUMOV, B. V., SHAKHRAY, O. G. and EYDUK, V. I.

[Abstract] Shadow TV instruments used for study of remote objects with variations of the refractive index in space produce visual images of transparent inhomogeneities. Fluctuations of the refractive index cause fluctuations of the phase of the light wave passing through the medium. Because frequency characteristic of such a system cannot be described by the modulation transfer function $m_2(\gamma)/m_1(\gamma) = T(\gamma)$, because the image intensity depends on the absolute phase shift relative to a constant phase ϕ_0 and not on a phase shift which is uniform throughout the field, the optical transfer function $m_2(\gamma)/\phi_1 = T(\gamma)/\phi_0 = T_{sh}(\gamma)$ is proposed instead. The latter becomes identical to the modulation transfer only when $\phi_0 = 1$. This concept is applied to a system consisting of a monochromatic source, a condensing lens, and a first objective with a point diaphragm in its focal plane, followed by a pair of second and third objectives and a television transducer behind. The illuminance distribution in the plane of the light-sensitive transducer plate tends toward a δ-distribution in the presence of a half-plane knife edge. The dependence of the modulation transfer function on tuning of the knife position and on the amplitude of transparency phase oscillations has been evaluated by way of numerical integration on a digital computer for a one-dimensional phase grating. The illuminance profile of the image of a sinusoidal phase transparency in the transducer plane as well as the modulation transfer function have been calculated. The illuminance profile of the image of a standard phase inhomogeneity, a V-groove of various widths, was also calculated in order to determine the accuracy of calculating the instrument response to a nonperiodic inhomogeneity in the geometrical-optics approximation. The results indicate that narrowing the open part of the light diaphragm increases the image contrast and widens the passband toward lower frequencies, thus increasing the sensitivity to the gradient of refractive index in the low-frequency range. Figures 4; references 7: 6 Russian, 1 Western in translation.
[217-2415]

CIRCUITS AND SYSTEMS

UDC 519.217

OPTIMAL NONLINEAR ESTIMATION OF SIGNAL WITH JUMPWISE VARYING PARAMETERS

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 26, No 1, Jan 83 (manuscript received 9 Mar 82) pp 49-57

MAL'TSEV, A. A. and SILAYEV, A. M., Gorkiy State University

[Abstract] The problem of optimal exact estimation is solved for a signal with random jumpwise variations of its parameters or of its reading. The occurrence of such jumps is assumed to be sufficiently infrequent to allow separate estimation of each one in the m-dimensional random vector process $y(t) = s\,[x(t);1(t-\tau] + n(t)$, where x(t) is the state vector, n(t) is the vector of mutually independent Gaussian white noise processes with statistical characteristics $\langle n_\alpha(t)\rangle = 0$, $\langle n_\alpha(t_1).\ \ n_\alpha(t_2)\rangle = (N_\alpha/2)\delta(t_2 - t_1)$, $\alpha = 1,2,\ldots,m$, and $s[x(t);1(t-\tau)]$ is an m-dimensional vector depending on vector x(t), c time t, and on the unit step function $1(t-\tau)$ (τ- instant of time of jump in reading). The components of the state vector x(t) are assumed to form a Markov set statistically independent of the noise vector n(t), and the probability density of the vector process x(t) is assumed to satisfy the a priori equation $\partial W_x(x,t)/\partial t = LW_x(x,t)$

$$L(\cdot) = \begin{cases} L_0(\cdot), & t \le \tau \\ L_1(\cdot), & t > \tau \end{cases}$$

According to the general theory of conditional Markov processes, the a posteriori probability density of the Markov set $|x,t|$ is described by the Stratonovich equation with the appropriate initial condition. Equations for the auxiliary probability density functions $W_0(x,t)$ and $W_1(x,t)$ introduced here are derived constructed through differentiation of the products of these functions by the corresponding weight factors $p_0(t)$ and $p_1(t)$. Closure of the system of equations requires the a posteriori probability density $W_\tau(t,t)$ of a jump at instant $\tau = t$ and the conditional probability density $W_{x/\tau}(x/t,t)$ of x-distribution at that instant of time. Solution of this system of equation yields not the optimum estimate but the optimum median estimate of the jump or switching time. A more precise estimate requires solution of a more intricate equation for $W_\tau(\tau,t)$. For illustration is considered a signal at the receiver

$$y(t) = \begin{cases} A\sin\omega_0 t + n(t), & t \leq \tau \\ A\sin(\omega_0 + \Omega) + n(t), & t > \tau \end{cases}$$

with known amplitude A and frequency ω_0 but unknown frequency jump Ω at an unknown instant of time τ. References: 6 Russian.
[216-2415]

COMMUNICATIONS

UDC 621.372.54

FEATURES OF MICROPROCESSOR IMPLEMENTATION OF ALGORITHMS FOR SPACE-TIME PROCESSING OF SIGNALS AND NOISE IN RADIOELECTRONIC SYSTEMS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian Vol 26, No 3, Mar 83 (manuscript received 17 Aug 82 after revision) pp 52-55

[Article by V.V. Popovskiy and Ye.I. Glushankov]

[Text] This study analyzes the possibility of microprocessor implementation of a multidimensional Kalman filter which supports space-time signal and noise processing. One implementation on the K587 LSI microprocessor system is cited.

We shall examine a discrete algorithm for optimal space-time processing of signals and noise which provides minimal mean-square error between the standard signal $z_s(t)$ and the received signal z(t).

The state of the weight coefficient vector (WCV) of the antenna array $\vec{w}(t)$ and the signal z(t) at the output of the space-time processing device can be assigned in the form of stochastic linear difference equations [1]:

$$\vec{w}(k+1) = F(k)\vec{w}(k) + G(k)\vec{n}(k), \tag{1}$$

$$z(k) = \vec{H}^{\tau}(k)\vec{w}(k) + v(k), \quad (\ )$$

where $\vec{n}(k)$ and v(k) -- uncorrelated white noise of model and observation with null mean and covariation

$$\mathrm{cov}\{\vec{n}(k), \vec{n}(l)\} = V_{\vec{n}}(k)\,\delta(k, l), \qquad \mathrm{cov}\{v(k), v(l)\} = V_v(k)\,\delta(k, l).$$

F(k), G(k) -- assigned matrices; $\vec{H}(k)$ -- vector of signals received by antenna elements of array; δ - Kronecker symbol.

The linear recursive processing algorithm can be used to estimate the WCV $\vec{w}(k)$ by the received signals $\vec{H}(k)$ and the existing standard $z_s(k)$ by solving the following Kalman-Busey filter equations [2]:

$$\hat{\vec{w}}(k) = F(k)\,\hat{\vec{w}}(k-1) + K(k)\,[z_s(k) - \vec{H}^T(k)\,F(k)\,\hat{\vec{w}}(k-1)], \tag{3}$$

$$K(k) = V_{\tilde{\vec{w}}}(k\,|\,k-1)\,\vec{H}^T(k)\,[\vec{H}(k)\,V_{\tilde{\vec{w}}}(k\,|\,k-1)\,\vec{H}^T(k) + V_s(k)]^{-1}, \tag{4}$$

$$V_{\tilde{\vec{w}}}(k\,|\,k-1) = F(k)\,V_{\tilde{\vec{w}}}(k-1\,|\,k-1)\,F^T(k) + G(k)\,V_{\vec{n}}(k)\,G^T(k), \tag{5}$$

$$V_{\tilde{\vec{w}}}(k\,|\,k) = [I - K(k)\,\vec{H}(k)]\,V_{\tilde{\vec{w}}}(k\,|\,k-1), \tag{6}$$

$$\hat{\vec{w}}(0) = \langle \vec{w}(0) \rangle, \quad V_{\tilde{\vec{w}}}(0\,|\,0) = V_{\vec{w}}(0). \qquad (\ )$$

where $\hat{\vec{w}}(k)$ -- estimate of WCV $\vec{w}(k)$; K(k) -- filter gain; $\tilde{\vec{w}}(k)=\vec{w}(k)-\hat{\vec{w}}(k)$ -- WCV estimation error; $V_{\tilde{\vec{w}}}(k|k)$ -- a posteriori dispersion of estimation error; I -- identity matrix.

Implementation of the recursive algorithm for estimating the WCV requires that formulas (5), (4), (3) and (6) be used in sequence. The discrete space-time processing algorithm in question can be implemented on a microprocessor operating in real time.

<u>Microprocessor requirements</u>. The computational requirements which must be satisfied in order to implement a multidimensional Kalman filter on a microprocessor can be divided into two parts: memory capacity requirements and speed requirements [3].

The memory capacity requirements are the same for different microprocessors, and are determined by the dimensionality of the matrices and vectors of the algorithm implemented. If $\vec{w}(k)$ is an n-dimensional vector (n -- number of antenna array elements); z(k) -- an m-dimensional vector, the requirements for memory capacity are shown in Table 1. The fourth column of the table shows the requirements in bytes for the case in which the components of all of the vectors and matrices are two bytes (16 bits) long and for n=m=4.

TABLE 1

Matrix/vector	Dimensionality	Memory required	Memory, bytes
$\hat{\vec{w}}$	n	n	8
F	$n\times n$	n^2	64
G	$n\times n$	n^2	64
$V_{\tilde{\vec{w}}}$	$n\times n$	n^2	64
$V_{\vec{\hat{w}}}$	$n\times n$	n^2	64
K	$n\times m$	nm	64
$\vec{H}$	$m\times n$	nm	64
V_0	$m\times m$	m^2	64
Z_0	m	m	8
Total			464

The speed requirements are determined by the total number of arithmetic operations which must be executed in implementing the algorithm. For one iteration, these requirements comprise the following:

$$N_1 = 5n^3 - 2n^2 + 3n^2m + 2nm^2 - nm - n, \quad (8)$$
$$N_2 = 5n^3 + n^2 + 3n^2m + 2m^2 + 2nm, \quad (\;)$$

where N_1 -- number of additions and subtractions; N_2 -- number of multiplications and divisions. It is clear from formulas (8)-(9) that the fundamental operation in implementing a multi-dimensional space-time processing algorithm based on a Kalman filter will be the multiplication operation.* Therefore, the choice of microprocessor must make allowance for its overall speed, as well as the multiplication speed, which is higher in microprocessors with hardware multiply (microprocessor systems in LSI series K587, K588, U83-K1883, KR1802, KR1804 [4]).

Software. Any algorithm is implemented on a microprocessor by a program which is stored in read-only or random-access memory in the corresponding microprocessor system. Figure 1 shows one version of the flowchart of an algorithm for microprocessor multiplication, where the following notation is employed: P, T, R, S -- additional files; M -- number of steps, which is usually found from the relationship

* Division is done only during matrix inversion in (4).

$$M > 1.5\tau_{cor}/\Delta t, \qquad (10)$$

where Δt -- digitization interval; τ_{cor} -- correlation interval. The efficiency of the algorithm depends in many respects upon the choice of Δt. Figure 2 shows various plots of the normalized a posteriori dispersion of the error of estimating $V_{\vec{w}}(j|j)/V_{\vec{w}}(0|0)$, calculated by formula (6), as a function of time for various Δt. Curve 1 corresponds to a digitization step $\Delta t=0.01\tau_{cor}$; curve 2 — $\Delta t=0.1\tau_{cor}$; curve 3 -- $\Delta t=1.7\tau_{cor}$; curve 4 -- $\Delta t=1/3\tau_{cor}$. All of these curves are plotted for a signal power to noise power ratio in the receiving frequency band of $P_s/P_n=10^3$.

It is apparent from Fig. 2 that increasing the digitization step results in a sharp increase in the a posteriori dispersion of the estimation error, and even to divergence of the algorithm (curve 4 in Fig. 2), which is explained by the reduced statistical connection between the sampled values. Reducing the digitization step makes it necessary to use faster computing devices to implement the Kalman filter. Since microprocessors are relatively slow, the problem of choosing the digitization step is one of the most important stages in designing microprocessor-based systems. Within time Δt it is necessary to perform one iteration by the algorithm assigned by formulas (3)-(6) (blocks 5-23 in Fig. 1).

Our investigations indicated that for communications channels in which τ_{cor} has a value of tenths of seconds, real time implementation of the processing algorithm on a microcomputer based on the K587 LSI series [4] requires that $\Delta t=0.05\tau_{cor}$ for the two-dimensional case (n=m=2) and $\Delta t=0.1\,\tau_{cor}$ for the four-dimensional case (n=m=4). As the dimensionality of the antenna array increases (n>4), a computer system consisting of several microprocessors operating in parallel must be used.

When such a computing system is employed, the algorithm can be paralleled in the following way. Each iteration will be executed in several steps. In the first step equation (5) is solved in parallel and the value of $\hat{F}(k)\vec{w}(k-1)$ and $[z_s(k)-\vec{H}(k)F(k)\hat{\vec{w}}(k-1)]$ in equation (3) are determined. The second step is to solve equation (4) and determine the value of $H(k)V_{\vec{w}}(k|k-1)$ in (6). The third step is to solve equations (3) and (6). This paralleling of the algorithm makes it possible to reduce the amount of computation in one iteration for n=m=8 by 21% for addition and subtraction, and by 23% for multiplication and division. In addition, it is possible to execute the

matrix multiplication and addition operations in parallel in solving the vector-matrix equations in the algorithm.

The present microprocessor synthesis method, which supports space-time processing of signals and noise in radioelectronic systems, can be recommended for small antenna arrays with approximately 6-12 receiving elements when the dimensions, weight and power resources are limited.

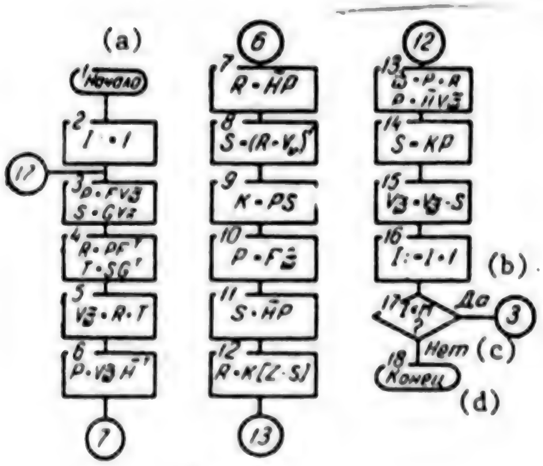

Fig. 1

Key: (a) -- start; (b) -- yes; (c) -- no; (d) --end

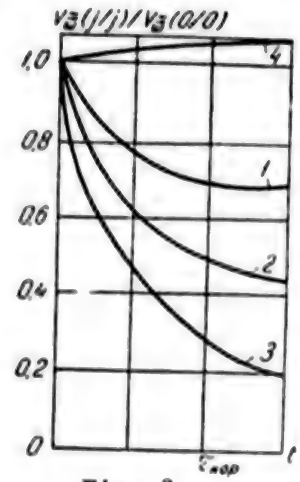

Fig. 2

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CSO: 8144/1272

UDC 621.391.2

PSEUDORANDOM SIGNAL DELAY SEARCH USING ACOUSTOELECTRIC CONVOLVERS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian Vol 26, No 3, Mar 83 (manuscript received 9 Nov 81) pp 62-65

[Article by A.B. Kuzichkin]

[Text] This study investigates characteristics of implementing step delay search of pseudorandom signals using a new class of devices for processing long complex signals which are constructed on the basis of an acoustoelectric convolver [1,2] and a coherent accumulator [3,4]. The algorithm by which signals are processed by these devices includes segment-by-segment matched filtering of the received signal in the acoustoelectronic convolver and coherent accumulation of the convolver output signals in a coherent accumulator, which can consist of recirculating delay lines [3,5] or shift registers employing charge-coupled devices [4].

In contrast to matched filters, acoustoelectronic convolver-coherent accumulator devices are invariant to delay of the received signal. For example, when a recirculating delay line is employed as the coherent accumulator, an acoustoelectronic convolver-coherent accumulator device can process pseudorandom signals only when the signal falls within the time window of the discrimination characteristic

$$D(\Delta\tau)=\begin{cases}1-|\Delta\tau|/2T_d, & |\Delta\tau|<2T_d,\\ 0 & |\Delta\tau|>2T_d,\end{cases}$$

where $\Delta\tau$ -- time offset between received signal and reference signal of convolver ($\Delta\tau<0$ if the reference signal leads the received signal; $\Delta\tau<0$ if the reference signal follows the received signal); T_d -- signal delay in region of nonlinear operation of the acoustoelectric convolver (the typical value of T_d ranges from 10 to 40 μsec).

Another feature of the acoustoelectric convolver-coherent accumulator device is the impossibility of determining the delay of the received signal by the

time Δt_{kp} of appearance at the output of the coherent accumulator of the correlation peak which is formed when the acoustic analogs of the received signal and reference signal coincide spatially in the region of nonlinear operation of the acoustoelectronic convolver. The reason for this ambiguity is the fact that the relationship between Δt_{kp} and $\Delta\tau$ depends upon the sign of $\Delta\tau$:

$$\Delta\tau = \begin{cases} 2(\Delta t_{kp} - T_d), & \Delta\tau < 0, \\ 2\Delta t_{kp}, & \Delta\tau > 0, \end{cases}$$

where the time Δt_{kp} is counted from the time at which the signal starts to be read from the coherent accumulator, which is done after the required numl :r of accumulation cycles have been completed.

Using the Markov chain method, and assuming that a decision that a correlation peak has been detected in the output signal of the processing device is made by the maximum of the a posteriori probability, we obtain the following expression for the average convolver pseudorandom signal signal search time:

$$\bar{T}_p = \frac{2D - P_0(D-1)}{2P_0}\left[\frac{\Delta T_n}{\Delta T_{sh} D}(I+1)T_d + T_k\right], \tag{1}$$

where ΔT_n -- size of zone of indeterminacy of received signal delay; ΔT_{sh} -- received-signal delay search step; D -- number of partial received signal search zones ($D=1,2,\ldots, \Delta T_n/\Delta T_{sh}$), after the analysis of each of which is completed a decision is made that a correlation peak has been detected; I -- number of accumulation cycles of output signal from acousto-electric convolver in coherent accumulator; P_0 -- probability of correct detection of correlation peak bearing information regarding delay in the received signal while analyzing the partial zone of indeterminacy $\Delta\Omega=\Delta T_n/D$ containing the pseudorandom signal; T_k -- duration of test procedure, during which the decision that a correlation peak has been detected is verified and any ambiguity in determining the delay of the received signal is determined by the time of occurrence of the correlation peak detected

$$T_k = 2T_d h_k^2/qB; \tag{2}$$

h_k^2 -- signal/noise ratio at output of convolver-accumulator device needed to ensure the required accuracy of the test procedure; q -- signal/noise ratio at input of processing device; B -- base of pseudorandom signal segment processed by convolver without accumulation.

In order to find the probability P_0 we shall assume that during a single inspection of the zone of indeterminacy ΔT_n, several correlation peaks will be observed at the output of the coherent accumulator whose time of appearance is associated with the delay of the received signal (the Q of these correlation peaks depends upon the size of the search step. For example, for $\Delta T_{sh}=T_d$ Q=4, and for $\Delta T_{sh}=2T_d$ and $\Delta T_{sh}=3T_d$ Q=2). In connection with this, if the accuracy with which $\Delta\tau$ is defined is comparable to the duration of an elementary pseudorandom signal element, the expression for P_0 can be written as follows:

$$P_0 = 1 - \prod_{i=1}^{Q} (1 - P_i). \qquad (3)$$

where P_i -- probability that the magnitude of the ith correlation peak $(i=\overline{1,Q})$ will be greater than all noise spikes at the output of the processor when analyzing the partial zone of indeterminacy containing the pseudorandom signal.

During incoherent reception of a pseudorandom signal against the background of white Gaussian noise [6]

$$P_i = \int_0^\infty u \exp[-(u^2 + h_i^2)/2]\, I_0(h_i u)\, [1 - \exp(-u^2/2)]^M du,$$

where

$$h_i^2 = \begin{cases} qB/(1 - |\Delta\tau_i|/2T_d)^2, & |\Delta\tau_i| < 2T_d, \\ 0 & |\Delta\tau_i| > 2T_d, \end{cases} \qquad (4)$$

$\Delta\tau_i$ -- delay of received signal producing ith correlation peak at output of device; $I_0(\cdot)$ -- modified zero order Bessell function of the first kind; M -- number of uncorrelated noise spikes at output of coherent accumulator during analysis of one partial zone $\Delta\Omega$

$$M = (2B\Delta T_d/\Delta T_{sh} D) - Q. \qquad (\ )$$

Analysis of formulas (1)-(5) indicates the possibility of minimizing the average pseudorandom signal search time by optimizing the parameters ΔT_{sh}, I and D (the rest of the parameters are assumed to be given). This optimization problem was solved for the worst-case conditions of detecting the received signal (for the worst initial offset values $\Delta\tau$), using as the efficiency function the average value of the maximum pseudorandom signal search time:

$$\bar{T}_{p\max}(\Delta T_{sh\,opt}, I_{opt}, D_{opt}) = \min_{(\Delta T_{sh}, I, D)} \bar{T}_{p\max}(\Delta T_{sh}, I, D),$$
$$\Delta T_{n}, T_{p}, B, q, h_{k}^{2} = \text{const.}$$

The optimal values were found for the parameters I, D and ΔT_{sh} by finding the unconditional local minimum of $\bar{T}_{p\,\max}$ in the space D, I, ΔT_{sh}, which involves solving the following system of equations:

$$\left.\begin{aligned} &\partial\bar{T}_{p\max}/\partial D = 0 \\ &\partial\bar{T}_{p\max}/\partial I = 0 \\ &\partial\bar{T}_{p\max}/\partial\Delta T_{sh} = 0 \end{aligned}\right\}.$$

which after substituting expressions (1) and (2) is transformed to the following form:

$$\left.\begin{aligned} &\frac{D-1}{2D}P_0^2 + \left[(I+1) + 2\frac{LDR}{Z}\right]\frac{\partial P_0}{\partial I} - P_0 = 0 \\ &\left[\frac{Z(I+1)}{2LD^3} + R\right]P_0^2 - 2RP_0 + \left[\frac{Z(I+1)}{L} + 2RD\right]\frac{\partial P_0}{\partial D} = 0 \\ &P_0 + \left[\Delta T_{sh} + \frac{2RD\Delta T_{sh}^2}{ZT_0(I+1)}\right]\frac{\partial P_0}{\partial\Delta T_{sh}} - \frac{D-1}{D} = 0 \end{aligned}\right\} \quad (6$$

where $Z=\Delta T_n/T_d$; $L=\Delta T_{sh}/T_z$; $R=h_k^2/qB$.

The results of solving system (6) numerically by computer are plotted in Figs. 1-3. For example, Fig. 1 illustrates the optimal search step size as a function of the signal/noise ratio at the input of the processor for a number of values of Z and B (1-$Z=10^4$, $B=10^3$; 2-$Z=10^3$, $B=10^3$; 3-$Z=10^4$, $B=10^2$; 4-$Z=10^3$, $B=10^2$; 5-$Z=10^2$; $B=10^2$). It is apparent that the optimal search step size lies in the interval $(1.45\div1.5)T_d$ throughout practically the entire range of input signal/noise ratios and segment base B typical of most pseudonoise signal applications ($q=10^{-2}\div10^{-3}$; $B=10^2-10^3$).

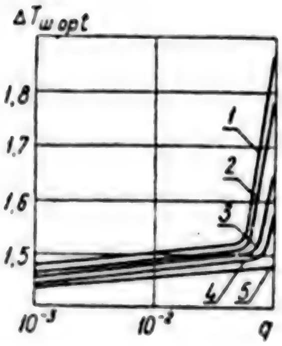

Fig. 1

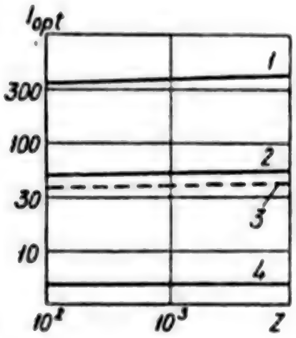

Fig. 2

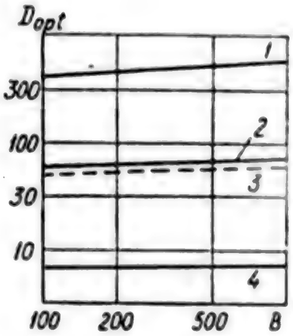

Fig. 3

Figures 2 and 3 show plots of the optimal values of D and I for the optimal search step as a function of various parameters of the received signal (Fig. 2: 1-$q=10^{-3}$, $B=10^2$; 2-$q=10^{-3}$, $B=10^3$; 3-$q=10^{-2}$, $B=10^2$; 4-$q=10^{-2}$, $B=10^3$. Figure 3: 1-$q=10^{-3}$, $Z=10^4$; 2-$q=10^{-3}$, $Z=10$; 3-$q=10^{-2}$, $Z=10^3$; 4-$q=10^{-3}$, $Z=10^2$). As follows from these functions, the quantity I_{opt} is determined primarily by the input signal/noise ratio q and the value of the segment base B, while the quantity D_{opt} depends, as a practical matter, only upon the size of the normalized indeterminacy zone $Z=\Delta T_n/T_d$.

Analysis of the sensitivity of this step convolver search algorithm to deviation in the parameters ΔT_{sh}, I and D from their optimal values indicates that the speed with which a convolver-accumulator device finds the pseudo-random signal is influenced most strongly by the extent to which the device agrees with the received signal in terms of the size of the parameter I (e.g., when searching for a pseudonoise signal using a processing device which is optimized for the case $q=10^{-3}$, $B=10^3$ and $Z=10^3$, the divergence in the parameter I resulting from a change by an order of magnitude in the input signal/noise ratio degrades the speed of the search algorithm by approximately a factor c 30, while the deviation in the parameter D which occurs when the zone of

indeterminacy of the delay of the received signal changes by a factor of 10 increases the average search time by no more than a factor of 1.5, and divergence in the search step which occurs when q and Z vary over the entire range of practical interest reduces the search speed by only 0.2-0.5%). In connection with this, implementation of the pseudonoise signal delay search algorithm requires special steps to adapt the acoustoelectronic convolver-coherent accumulator processing device to variation in the input signal/noise ratio, even though threshold decision rules are not employed in detecting the signal.

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UDC 621.317.772.5

FACTORIAL EXPERIMENT FOR DESIGN OF OPTOELECTRONIC DEVICES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 1, Jan 83 (manuscript received 2 Mar 82) pp 1-3

GOS'KOV, P. I., PUSHNIKOV, A. G. and TITOV, V. S.

[Abstract] The method of full factorial experiments is applied to the design of optoelectronic devices, with a mathematical model adequate for qualitative and quantitative analysis of influence factors on design and performance indicators. Such a model also renders a geometrical interpretation, in the form of isolevel lines, of changes in a response function resulting from simultaneous variation of several factors. The attendant problem of scanning the response surface for optimum design involves search for the conditional extremum of a response function within the part of the factorial space covered by the experiment, under constraints imposed by other response functions. Here a graphoanalytical procedure is proposed which involves evaluation of polynomial relations, construction of isolevel lines, and application of the Lagrange method. The procedure is demonstrated on the example of the function $Y_e = 6 - 4X_1 - 3X_2$ = max with constraint $Y_1 = X_1^2 + X_2^2 = 1$, a typical application being a mosaic-type optoelectronic position transducer with a static characteristic (output signal vs. deviation) required to be linear within a given tolerance. The nonlinearity, a periodically oscillating quantity, and the optimum design parameters for a given slope of this characteristic have been calculated by this procedure on the basis of a 2^3 factorial experiment. Figures 2; references: 5 Russian. [217-2415]

UDC 621.385.833

ELECTRON-BEAM SET ELA-50/5

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 1, Jan 83 (manuscript received 20 May 81) pp 40-43

VASICHEV, B. N., KABANOV, A. N., BDULENKO, A. P., ROZENFEL'D, L. B., POLIVANOV, V. V., SKOROMNIKOV, Yu. N., KLYUYKOV, A. G. and PANTELEYEV, N. I.

[Abstract] The electron-beam set ELA-50/5 was developed and built for welding materials such as structural steel. Designed to produce seams of proper depth and width in accordance with modern technological requirements, it consists of an electron-optical column, a control stand, and a high-voltage module. As cathode is used either a 0.02 mm thick and 1-2 mm wide tungsten foil or 0.05 mm thick and 1-2 mm wide tantalum foil. The electron-optical column contains an electron gun with beam control and heat sink, a focusing lens with adjustable deflection system, and a 25 W motor-driven vacuum cutoff valve. The beam current is regulated by regulation of the bias voltage. The maximum accelerating voltage is 50 kV. The maximum continuous beam current is 100 mA. Current pulses for welding, of up to 150 mA amplitude and 10-160 millisecond duration, are generated by a 1000 V chopper with a maximum duty factor of 50%. The minimum beam diameter at 10 mA and at a standard 300 mm distance from the lens is 0.5 mm. The maximum power is 5 kW continuous and 7.5 kW in pulse mode of operation. Figures 3; tables 1; references: 1 Russian.
[217-2415]

UDC 531.7

PHOTOELECTRIC INSTRUMENT FOR INSPECTION OF WORKING DISTANCE OF PHOTOGRAPHIC OBJECTIVES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 1, Jan 83 (manuscript received 23 Dec 81) pp 24-26

ASTASHKIN, V. P., PODOBRYANSKIY, A. V., KHLEBNIKOV, F. P. and CHURILIN, V. A.

[Abstract] A photoelectronic instruments has been developed for automatic inspection, before final assembly, of photographic objectives. Its method of operation is based on harmonic analysis of the optical image of a test object and locating the plane of maximum contrast. For automatic focusing the sum is used of two signals corresponding to two space frequencies, respectively, one close to zero and one within the 20-40 lines/mm range. The instrument consists of a light source, a condensing lens, a diaphragm with slit, a collimator objective, a mirror, a microscope objective, an electromagnetic generator, a raster grating, a photomultiplier, and amplifier, a detector, a phase detector, a filter, an electric gear motor, an indicator, a linear-displacement transducer, and a digital display panel. An image is scanned by the microscope objective moving, driven by the generator, along the optical axis. The instrument is designed for checking objectives with focal lengths from 20 to 80 mm and stops from 1/1.5 to 1/4. It is adjusted for operation by the comparison method, using an objective with known working distance as reference. It has been checked for phase variation in the output signal and for defocusing. Also the change of working distance and the modulation transfer coefficient, both as functions of the objective orientation angle (0-360°), have been determined. The instrument was tested on a batch of "Gelios-44" objectives for statistical evaluation of its performance characteristics. Figures 5; references: 3 Russian.
[217-2415]

UDC 621.398.694.?

EFFECT OF MANUFACTURING IMPRECISION ON LAW OF VARIATION OF OUTPUT SIGNALS FROM RASTER-TYPE SINE-COSINE ANGLE TRANSDUCER

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 1, Jan 83 (manuscript received 12 Jan 81) pp 12-15

KHAYNATSKIY, O. A.

[Abstract] Raster-type sine-cosine angle transducers generating pairs of harmonic signals in phase quadrature are used in automatic and measuring systems requiring high accuracy. The accuracy of these devices depends largely on the manufacturing precision. A general equation for the output signal is derived here for evaluating the effects of manufacturing errors, when they appear together, on the performance, i.e., variation of amplitudes and phases of space harmonics in the outputs signals from transmitter and receiver rasters as a function of the angular coordinate. The results of this evaluation can serve as a basis for optimization of the manufacturing tolerances for a required degree of transducer accuracy. As an illustration, this method of analysis is applied to a photoelectric angle transducer with radial rasters having four kinds of manufacturing errors: 1) Error in width of radial lines; 2) Error in pitch of radial lines; 3) Nonparallelism of end faces; and 4) Eccentricity of geometrical axes. Conditions are established which, when satisfied, will minimize the effects, respectively, of the low-frequency last two errors and the high-frequency first two errors. Figures 1; references: 6 Russian.
[217-2415]

MICROWAVE THEORY AND TECHNIQUES

UDC 534.232.082.74

LOSS DEPENDENCE OF CHARACTERISTICS OF SURFACE-ACOUSTIC-WAVE RESONATOR WITH DISTRIBUTED FEEDBACK

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 26, No 1, Jan 83 (manuscript received 9 Mar 82) pp 103-109

PASKHIN, V. M., SANDLER, M. S. and SVESHNIKOV, B. V.

[Abstract] The characteristics of long interdigital transducers as SAW resonators are analyzed, with losses which limit the Q-factor taken into account. These losses are essentially diffraction losses and propagation losses, the latter including dissipation in the substrate and emission of volume waves into the ambient medium. The equation of motion for the amplitudes of coupled modes is formulated accordingly, with insertion of transverse Fourier components of the acoustic field. Integration over the entire spectrum yields the acoustic admittance of the system in form of an integral of an algebraic-trigonometric function. The power corresponds to the real part of this admittance and depends on attenuation as well as diffraction, both of which widen the resonance line. Their effect is evaluated in terms of three characteristic scales: 1) Length of attenuation path associated with propagation; 2) Length of diffraction path associated with widening of the beam aperture; and 3) Equivalent length of the delay line sufficient for attainment of a given Q-factor. The amplitude-frequency characteristic and the dependence of the normalized Q-factor on the normalized length of loss path have been determined experimentally for a delay line consisting of an interdigital transducer pair on an ST quartz. Figures 2; references 11: 8 Russian, 3 Western.
[216-2415]

UDC 621.375.8:621.318.134.029.64

NONRECIPROCAL ELEMENT BUILT WITH HEXAFERRITES FOR MILLIMETER-WAVE MASER AMPLIFIERS

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 26, No 1, Jan 83 (manuscript received 18 Nov 81) pp 120-125

SMIRNOVA, T. A. and CHERPAK, N. T., Institute of Radiophysics and Electronics, UkSSR Academy of Sciences

[Abstract] The feasibility of producing a nonreciprocal element with hexaferrites, for traveling-wave paramagnetic maser amplifiers, is demonstrated on such an amplifier with an andalusite crystal as active medium in the combline retarding structure. The selection of material is based on the characteristics of the resonance (EPR or FMR) field, with a uniaxial hexaferrite element treated as a long ellipsoid of dimensions much smaller than the wavelength. Available materials include $BaNi_2Sc_xFe_{16-x}O_{27}$ ($BaNi_2Sc_xW$) and $SrNi_2Cr_xFe_{16-x}O_{27}$($Ni_2SrCrW$). Particularly suitable for this application are grain-oriented specimens. For such materials have been determined the temperature dependence of the effective anisotropy field induction, dependence of the latter and of the resonance line width on the strontium or chromium content (x), and the dependence of the resonance frequency on the field current with hexaferrite wafers in a waveguide. Experiments were also performed with grades 07SChA and 06SChA ferrite ($BaNi_2W$, Sr = 0) in an electrodynamic structure at 4.2 and 300 K. The resonance absorption was found to decrease with increasing distance between active crystal and hexaferrite wafer and a nonreciprocality coefficient R = 30 was found to be attainable through optimization of the geometry. The authors thank V. I. Ivanova and I. I. Petrova for synthesizing the hexaferrite specimens. Figures 5; references 13: 11 Russian, 2 Western. [216-2415]

QUANTUM ELECTRONICS/ELECTRO-OPTICS

UDC 535.338

NONLINEAR OPTICAL INDICATION IN FREQUENCY STABILIZATION SYSTEMS

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 26, No 1, Jan 83 (manuscript received 7 Sep 81, after final revision 10 Jun 82) pp 29-35

BUDKIN, L. A., MITYUGOV, V. V., PIKHTELEV, A. I. and YASHINA, A. N.

[Abstract] Use of nonlinear laser spectroscopy for frequency stabilization of a quartz oscillator relative to a standard transition in vapor of an alkali metal is considered, the feasibility of this method being based on population redistribution caused by even a slight change in absorption and on resulting nonlinear optical indication. Processes occurring in the resonator cavity are analyzed in terms of the behavior of an atom (Na, Cs, Rb) in both a radio-frequency field and an optical one, such an atom being regarded as a three-level system. The conditions for stable emission are established, particularly single-frequency emission in a monochromatic field, and the Doppler effect caused by nonlinear absorption is evaluated with thermal motion of atoms taken into account. Figures 4; references 12: 7 Russian, 5 Western (1 in translation).
[216-2415]

UDC 535:621

METHODS OF NONDESTRUCTIVE INSPECTION OF OPTICAL LASER COMPONENTS FOR SURFACE RESISTANCE TO RADIATION

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 1, Jan 83 (manuscript received 26 Mar 82) pp 49-56

OKATOV, M. A., POPLAVSKIY, A. A. and TAGANOVA, V. A.

[Abstract] The optical components of laser equipment must be checked for quality of surface treatment, which determines the surface resistance to radiation - a major factor influencing their performance. Here a survey is

made of nondestructive methods available for this purpose. These methods include spark testing based on scattering of radiation, spectrometic methods based on changes in the reflection coefficient or in the breakdown threshold, emission methods based on photocurrent or exoelectron current measurement, methods involving roughness measurement, on the basis of the $E\sigma^m$ = const relation (E- threshold electric field intensity of the light wave, σ- rms deviation of heights of asperities from mean surface profile, $m<1$ empirical material constant) or on the basis of light scattering, calorimetric and pyrometric methods, and the optico-statistical method. All these methods are applicable to a wide range of substrate and coating materials with a variously treated surface, by polishing or etching, they are each particularly suitable under specific conditions. They may also be selected on the basis of simplicity or speed. Fi ures 9; tables 4; references 55: 45 Russian, 10 Western (1 in translation).
[217-2415]

UDC 522.2:539.3

SOFTWARE FOR REFINED CALCULATION OF STRAINS IN STRESS-RELIEVED MIRRORS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 1, Jan 83 (manuscript received 26 Nov 81) pp 10-12

PAYMUSHIN, V. N., SAITOV, I. Kh. and DEREVENSKIY, V. D.

[Abstract] Telescope components for aero-space applications are stress relieved in order to meet stringent requirements, and residual strains must be calculated so that the behavior under real conditions can be predicted. An algorithm has been developed for strain calculations more precise than by conventional methods, specifically applicable to telescope mirrors with filler and coatings. It is based on numerical rather than unwieldy analytical methods and has been programmed in ALGOL-60 for an M-222 computer with TA-2M translator. It is now being rewritten in FORTRAN-4 for a YeS-1033 Unified System computer. It covers single-layer and double-layer coatings, with or without regular perforations in one (lower) layer, made of the same or different materials. It takes into account the temperature dependence of physicomechanical properties, transverse compression of the filler, effect of peripheral sheathing diaphragms, effect of changes in homogeneity and monolithicity of the material. It also covers fillers made of interlinked or separate hexagonal, triangular, square, and cylindrical cells. It yields the elasticity characteristics either according to standard program or according to user's input, also weight of the mirror and its behavior in various modes of unloading. Typical data are shown for a monolithic mirror with fused-quartz filler or with aluminum-foil filler. Figures 1; tables 1; references 5: 4 Russian, 1 Western.
[217-2415]

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DIFFERENTIAL RELATIONS FOR TWO-MIRROR TELESCOPE SYSTEMS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 1, Jan 83 (manuscript received 19 Nov 80) pp 15-16

MIKHEL'SON, N. N.

[Abstract] A two-mirror telescope system is considered in which both main and auxiliary mirrors have second-order surfaces. On the basis of known expressions for the coefficients of third-order coma and spherical aberration, differential relations are derived for the tolerances on radii of curvature, on eccentricities squared,aand on the widths of air gaps. These relations express the sensitivity of two principal system performance parameters, namely reciprocal of magnification by the auxiliary mirror and shielding factor (shielding of main mirror by auxiliary one at a point on the axis), to variations in those geometrical dimensions. They also yield changes in the location of the focal plane and in the focal length as functions of those dimensions. The applied, with appropriate modifications, to Cassegrain and Ricci-Cretien systems. References 2: 1 Russian, 1 Western.
[217-2415]

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